CTN Test Report 91-026

MODEL--ENGINEERING DATA

31 March 1992

Prepared for

Air Force Materiel Command

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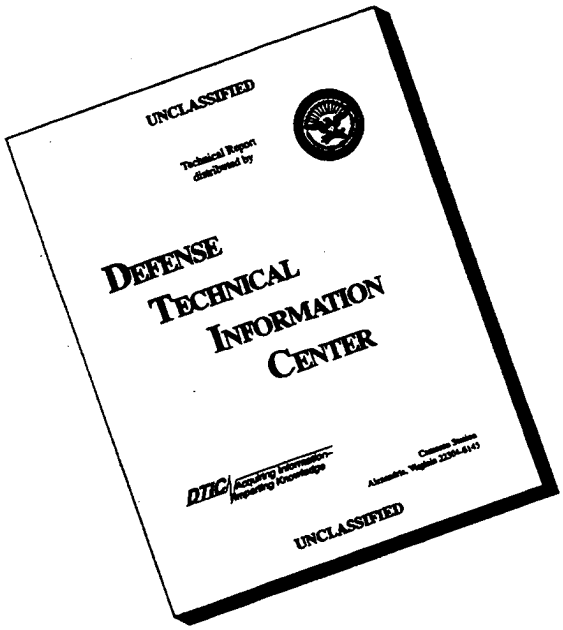

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FINAL

Model -- Engineering Data

Prepared For:

Air Force Materiel Command
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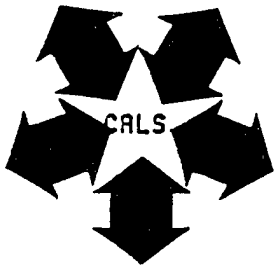

By:

Department of the Army

PM CALS

31 March 1992

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Model -- Engineering Data

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EXECUTIVE SUMMARY

This document presents a model which depicts the flow of engineering data from the contractor source to the government user destination. The government Quality Assurance (QA), Pre-Acceptance and Final Acceptance processes are included in the model for application to a variety of data procurement requirements.

The process model is of modular structure and provides for expansion of the functional blocks that are related to digital data acceptance. This organization also provides the flexibility for additions or expansions in the future as the CALS standards mature.

The product data model addresses engineering drawing data with emphasis on Raster Type I. Raster Type II and IGES data fit the model within the guidelines of CALS and the model can be expanded, as necessary, to apply computer-assisted data acceptance techniques to Raster Type II and IGES data in the future.

This document first introduces the model, the methodology used, and the CALS documentation types addressed. The model is then presented in terms of product data procurement as an overview of contractor and government interactions. The model next expands the contractor function to depict the Product Data Generation processes. The government functions are also expanded to show the Product Data Acceptance processes at the contractor site. Finally the model expands the common Data Pre-Acceptance function from each of these processes to show how computer-assisted Data Acceptance techniques can be applied.

A description of the application of computer-assisted techniques to the Pre-Acceptance of engineering data is provided. The model shows how the image quality and identification data (ID) can be analyzed to produce accept/reject reports for final analysis at an image workstation. Computer-Assisted Data Acceptance will greatly reduce the labor intensive viewing of digital data at an image workstation. The model identifies Pre-Acceptance modules at the contractor site and the government site where the Computer-Assisted Data Acceptance Procedures can be applied.

The acceptance of large amounts of digital data dictates the use of computer-assisted techniques to reduce the time consuming QA of the digital data. In order to predict performance, it will be necessary to determine the effectiveness and the extent of applicability of computer-assisted techniques. This can best be done by simulating key activities depicted in the model and by extensive testing of

applicable computer-assisted techniques. This testing is planned for the near future.

1.0 INTRODUCTION

The acquisition, acceptance, storage, management, distribution and use of data for the logistic support of weapon systems has long been a challenge for the member agencies of the Department of Defense (DoD). One of the biggest problems is that of obtaining and maintaining quality data. This problem has been recognized for many years by the DoD agencies and has been addressed by improving the data storage medium in terms of resolution, durability, and storage density. Micrographic media such as aperture cards were introduced to successfully reduce the data storage and distribution problems associated with the use of hard copy.

As weapon system technology advanced and complexity increased, the requirements for more support data increased. It is reported that there are now some 200 million source aperture cards in use by the DoD agencies. The manual storage, indexing, and management of the growing data base have again become a problem. More importantly, the quality of the data has suffered due to increased handling and duplication of the aperture cards. Technological advances of the last two decades in processing speed and power, mass storage speed and capacity, image processing, image scanners and image software have provided economic means of solving or at least minimizing many of these problems.

The DoD authorized the procurement of repository image management systems in the early 1980s to apply such technological advances toward the solution of the data management problems. A joint Army/Air Force procurement of the Digital Storage and Retrieval Engineering Data System (DSREDS)/Engineering Data Computer Assisted Retrieval System (EDCARS) resulted in the installation of 12 data repository sites. In late 1989, the Navy installed its first Engineering Data Management Information and Control System (EDMICS) repository system.

DSREDS/EDCARS and now EDMICS are all actively involved in the conversion of the aperture card data for active weapon systems to digital image data on mass storage media so that they can be ready for full production operations.

At least one problem still exists. How does the government know that the converted digital image data is of sufficient quality to store in their repositories? The government has qualified personnel that know how to view micrographic data for acceptance but they have limited experience in the acceptance of digital data in large volume. Presently, this is accomplished by viewing each image on a high resolution graphic workstation. This has proven to be labor-intensive, time consuming and error-prone. The acceptance of data therefore requires a high use of the repository resources which adversely impacts the repositories' prime

mission which is to store and distribute the data. When digital data is imported to the DSREDS/EDCARS/EDMICS systems,better means must be used to QA and accept the digital data.

A review of the existing DSREDS/EDCARS and EDMICS procedures was made and a set of manual data acceptance procedures, using the repository system, was developed and has been field tested at an Army DSREDS site. A review of the manual procedures and testing in the field has pointed up the need to minimize the manual-visual QA of each image at the repository. To accomplish this, there is a need to develop computer-assisted data acceptance procedures and to recommend alternatives for the implementation of the procedures (i.e.,contractor site, user site or both).

DoD recognized that the problems of data quality and the distribution of the data could best be solved by developing standards for the development and distribution of data in an electronic format. The Computer-Aided Acquisition and Logistic Support (CALS) initiative introduced in 1985 provided the basis of obtaining quality product and technical publication data in standard formats and on standard media. Industry is cooperating with the DoD in the development and testing of these standards. The Army CALS Test Bed was tasked to develop and test manual data acceptance procedures applicable to the existing DSREDS/EDCARS data repository systems. As part of the infrastructure modernization effort, the CALS policy office has directed the CALS Test Network (CTN) to develop procedures for the acceptance of product and technical publication data in CALS-compliant format.

One should not underestimate the difficulty of developing a common set of data acceptance procedures for the various tri-service data repository sites. The sites observe different operating procedures, deal with different data types, data formats, identification data, and use different hardware/software platforms.

It became apparent that there was a need to develop a model as a formal means of presenting an overview of the salient attributes of the repositories' requirements for the acceptance of data from its generation to its final destination. The model would be the basis for developing data acceptance procedures for engineering drawing raster and IGES data. The model would be of such modularity that it can be expanded in the future to include additional product data types or to track the evolution of CALS standards.

2.0 PURPOSE

This document presents a model which depicts the flow of engineering drawing data from the contractor source to the user destination.

The model describes, at a high level, the processing and databases involved in the acceptance of CALS-compliant digital engineering data by a government agency. The model is intended to be used for the development of manual and computer-assisted data acceptance procedures for use by the tri-services.

3.0 SCOPE

The model describes the major activities required to perform data acceptance of digital engineering data. Engineering data includes engineering drawings and associated lists. The model encompasses the entire contract period from contract award to the final acceptance and storage of data in an engineering drawing repository. It also includes the return of rejected contract deliverables to the contractor. The model also describes the government agency's activities in the process; the contractor's activities are shown only to the extent that they relate directly to digital data acceptance. Further details regarding the contractor's activities are omitted.

MIL-STD-1840A defines the product data file as engineering drawing data, application data, and numerical control data. However, the model addresses only engineering data. Application data and numerical control data can be addressed in the future when MIL-STD-1840A specifications are further developed. Both raster and IGES types of engineering data are encompassed in the model. However, raster data is emphasized because it is currently the predominant data type stored in the repositories.

4.0 APPROACH

Procedures and techniques used by selected government-owned digital data repositories were obtained and analyzed. The procedures and techniques were broken down into fundamental processes and databases to provide a baseline for the development of a model. Existing and proposed computer-assisted techniques and tools for dealing with digital image data were researched.

Modeling methodologies, techniques, and tools available to develop data models were reviewed. The model is documented with the use of process flow diagrams. A CASE tool was used to assist in preparing the model for presentation. The Gane & Sarson methodology was selected for the development of the process flow diagrams.

4.1 Methodology

The model is illustrated as a hierarchy of Gane & Sarson process flow diagrams. The process flow diagram describes a breakdown of an overall procedure. It shows data stores, processes which operate on them, and the data flow which supports the processing. The symbols used in the process flow diagrams are shown in the legend in Figure 1.

A process is shown as a rectangular figure labeled with the letter "P" with rounded corners. A process denotes a distinct procedure, step, or other breakdown of a larger process. A data store is a rectangular figure labeled with the letter "D" which is open on the right-hand side. A data flow is shown as a directed line segment which is connected to the origin of the data and the destination of the data. A data flow implies that the data exists temporarily while a data store implies some permanence.

Data stores are shown in the diagram without regard to the storage medium; data may be digital data, paper data, verbal data, etc. Data flows are shown in the diagram without regard to the transfer medium; data transfer may be via magnetic media, telecommunications, mail, spoken word, etc. Similarly, processing is shown without regard to the means by which it is accomplished; processing may be computer processing, machine processing, manual processing, etc.

A process flow diagram shows all data stores and processes and all possible data flows. For any possible scenario, a subset of all processes and data may be applicable. The diagram does not show the sequence of processes since the sequence may vary for each possible scenario.

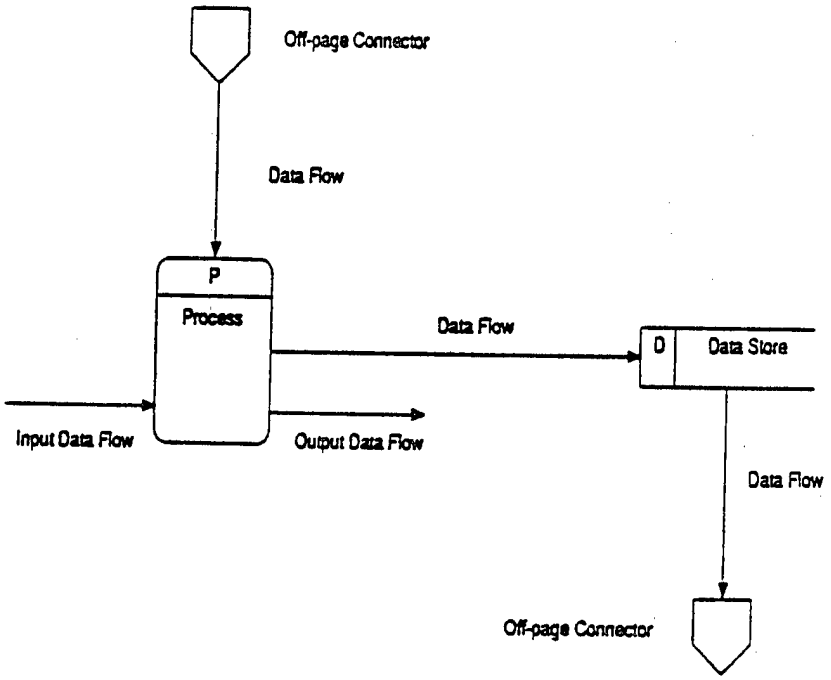

Figure 1 - Gane & Sarson Methodology Symbol Legend

4.2 Model

The digital data acceptance model describes functions within the product data procurement process for engineering drawing data. The model depicted provides an overview of the flow of data from the contractor's development to the final acceptance by the government at the user's site.

Emphasis is placed on the acceptance of the digital data at various stages in the development and delivery of the data on various media. The intent is to provide a model that will provide a broad, high level overview of where the data acceptance can be implemented. The model attempts to provide a number of options for application of data acceptance procedures. The resultant digital data acceptance procedures therefore may be implemented in a manner to meet the particular procurement requirements of data as specified in the contract. For example, a major weapon system procurement may require extensive reviews of the product data. This may include pre-acceptance of data at the contractor site by using computer-assisted data acceptance software residing on the contractor's system or residing on government furnished, stand-alone image platform(s). On the other hand, this same computer-assisted data acceptance software may be utilized only at the user site for low-volume data procurement and acceptance of data associated with engineering changes.

The model is not dependent on particular software or hardware platforms to perform the functions. For example, software providing computer-assisted techniques used in pre-acceptance can be installed on existing hardware or on new hardware purchased specifically to perform the function.

The model addresses a variety of transfer media by considering data in terms of files which have a logical structure which is independent of the physical medium or file system.

The application of the model functions is flexible in terms of the responsibility for performing the functions. For example, any functions which are performed by a contractor can also be performed by a subcontractor if the subcontractor has the resources to do so.

The Data Pre-Acceptance functional blocks are expanded in section 8.0, Data Pre-Acceptance, to describe the computer assisted techniques in greater detail.

4.3 Digital Documentation Types

The relationship among the various types of digital documentation which are defined in MIL-STD-1840A is shown in Figure 2. The digital documentation types addressed in the model are depicted by solid rectangles. Those not addressed are depicted by dashed rectangles.

Each type of data is shown with the section in MIL-STD-1840A which defines it or references it. Each type of data which is referenced but defined elsewhere is shown with the document and section which defines it.

Digital Documentation. This includes all data types described by MIL-STD-1840A. It is subdivided into Product Data and Technical Publications.

Product Data. Product Data consists of Engineering Drawing Data, Application Data, or Numerical Control Data.

Technical Publications. Technical Publications consist of text and associated illustrations. This type of data and its subdivisions are not addressed in this document.

Engineering Data. Engineering data consists of engineering drawing data, associated lists, and other related documents.

Engineering Drawing Data. This consists of digital representations of engineering drawings. It is subdivided into IGES Data and Raster Data.

Application Data. Electrical/electronic application data files are Class III application data subsets as specified by MIL-D-28000. This type of data and its subdivisions are not addressed in this document.

Numerical Control Data. Numerical control data files are Class IV application data subsets as specified by MIL-D-28000. This type of data and its subdivisions are not addressed in this document.

IGES Data. IGES engineering drawing data files are Class II application data subsets as specified by MIL-D-28000. They are vector representations of engineering drawing data.

Raster Data. Raster engineering drawing data files are described by MIL-R-28002.

Model -- Engineering Data

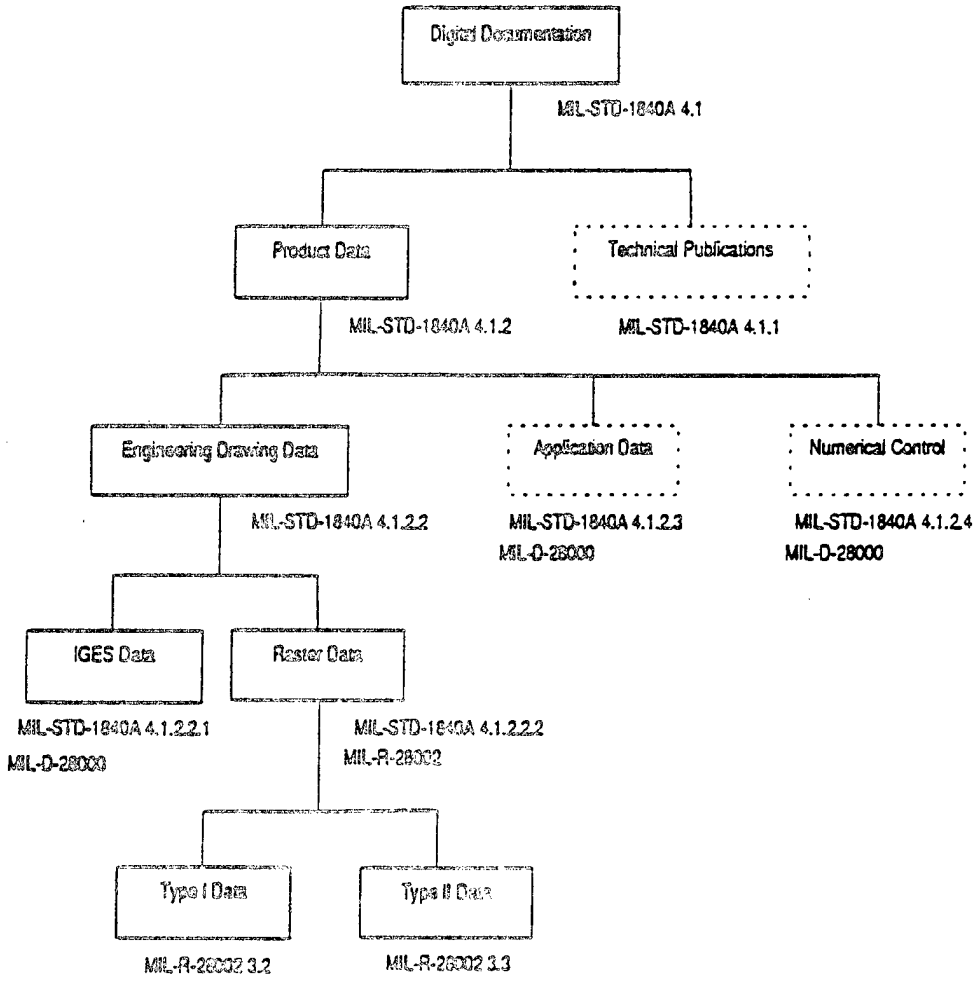

Figure 2 - Digital Documentation Types

Type I Data. Type I Raster Data consists of untiled engineering drawings.

Type II Data. Type II Raster Data consists of tiled engineering drawings.

5.0 PRODUCT DATA PROCUREMENT OVERVIEW

The Product Data Procurement process describes an overview of the major activities and exchange of materials between a government agency and a contractor. Product Data Procurement is shown in Figure 3.

The process begins with a Contract Award for the procurement of Product Data. This is followed by Contractor Validation which ensures that the contractor has a government-approved quality assurance program in place and has the capability to produce the deliverables specified by the contract.

Product Data Generation can start after contractor Validation is completed. This is a major activity which produces contract deliverables that will be sent to the government site.

Product Data Acceptance is performed for all product data contract deliverables sent by the contractor. Product data acceptance can be a multi-stage process in which pre-acceptance is performed at the contractor site or government site and final acceptance is performed at the government site. Product Data which is accepted is stored in the Engineering Drawing Repository. Product Data which is rejected is returned to the contractor for resolution.

The deliverable package will contain the deliverable files as specified in the contract and a data list created by the contractor. It is recommended that both be delivered in digital format and on media specified by the contract. The media may be magnetic tape, optical disk, floppy disk, telecommunications, or other media to be determined in the future.

The deliverable files will be classified in compliance with MIL-STD-1840A: a volume will contain one or more documents, a document will consist of one or more file sets, a file set will consist of one declaration file and one or more data files, a data file will contain the digital representation of one engineering drawing, and a data file will consist of a header record and one or more data records. Note that an engineering drawing may be one of several sheets for a drawing number; each sheet will be stored in a separate data file.

In the case of physical media, the deliverable package will consist of the deliverable files on the media in a properly labeled and sealed container which is shipped via the freight carrier specified in the contract. In the case of telecommunications media, the deliverable package will consist of a set of deliverable files which are transmitted from the contractor's system to the

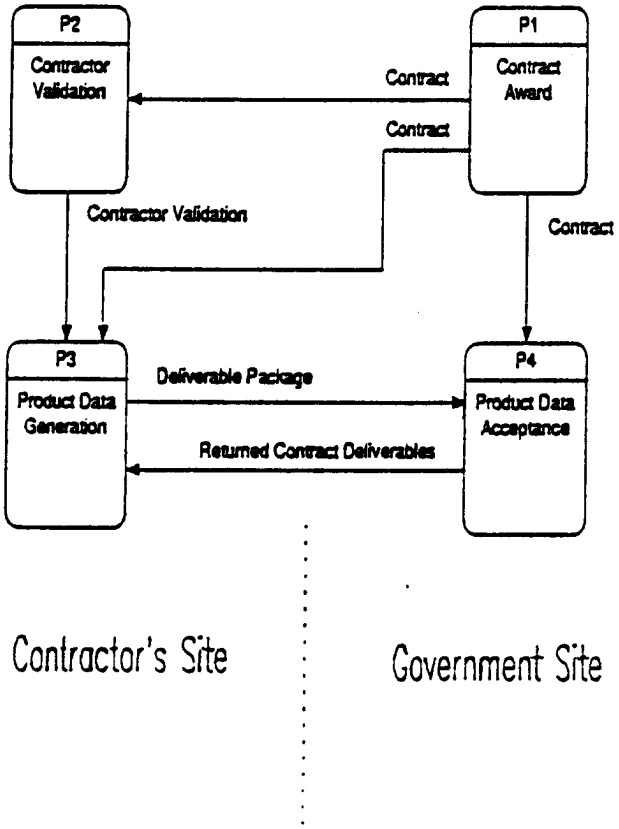

Figure 3 - Product Data Procurement

government agency system. The contract will specify that contract deliverables which do not comply with the requirements of the contract will be returned to the contractor.

Each of the Product Data Procurement functions are described below:

5.1 Contract Award (P1)

The process begins with the award of a contract by a government agency to a contractor for the purchase of weapon system data. The contract includes provisions for the purchase of production engineering drawings and defines the criteria for data acceptance and rejection. The contract issued by the government agency will include the Statement of Work (SOW), Contract Data Requirements List (CDRL), and Data Item Description (DID). It is used by the government agency for contractor validation, by the contractor for product data generation, and by the government agency for product data acceptance.

5.2 Contractor Validation (P2)

The contractor is subjected to a contractor validation process by the government agency. This determines that the contractor has a quality assurance program and resources in place and has demonstrated the capability to produce digital data in CALS-compliant format on media specified in the contract. The contractor will provide documentation of a government-approved quality assurance program to a government representative. The government will verify that the contractor has the capability to provide CALS-compliant data on the contract-specified media. In lieu of this previous government verification, the contractor will supply a sample data deliverable which will be subjected to format verification to verify that the deliverable is in CALS-compliant format.

5.3 Product Data Generation (P3)

Upon completion of Contractor Validation the contractor will produce a deliverable package of Product Data according to the terms of the contract.

A key part of Product Data Generation is the pre-acceptance of product data at the contractor site by a qualified government representative. As part of the contract, Product Data Generation has provisions for receiving returned contract deliverables from the government agency. These deliverables may have been rejected due to a variety of reasons: improper shipping, incorrect data, poor quality data, etc. See section 6.0, Product Data Generation, for additional details.

5.4 Product Data Acceptance (P4)

The government agency is notified that a package of contract deliverables from the contractor is ready for Pre-Acceptance.

A key part of the product data acceptance process is the pre-acceptance of product data. The government agency accepts the data in part or in whole and/or rejects it in part or in whole based on its compliance or non-compliance with the terms of the contract. Accepted data is stored in the Engineering Data Repository. Rejected data is returned to the contractor in the form of returned contract deliverables. See section 7.0, Product Data Acceptance, for additional details.

6.0 PRODUCT DATA GENERATION

Product Data Generation, as shown in the diagram of Figure 4, consists of the functions required to generate, QA and pre-accept product data at the contractor's site. It should be noted that the term "product data" is used to represent Raster Type I, Raster Type II, or IGES data. Each of the functional blocks are sequentially numbered (P3.1, P3.2, etc.) to assist in following the process flow. A number of common input and output items are shown with arrows. These include, Contract, Product Data, Rejected Product Data and Data List.

Data may be delivered and rejected data returned on physical media, such as magnetic tape or optical disk, or via telecommunication. The rejected physical media or files may be received and stored in a manner consistent with the method of transmission.

Product Data Generation is initiated upon receipt of the contract and after the Contractor Validation has been completed. The contractor will have completed the development of the R&D drawings, in-process technical reviews and now will generate the production-level product data.

As noted in Figure 4, the contractor will create a source database of product data and perform 100% quality assurance by visual inspection. Sampling QA of source data by a government representative will be conducted if specified in the contract.

The contractor will create deliverable files in CALS-compliant format and a data list of the deliverable files. The government will then perform on-site pre-acceptance of the data as specified in the contract. Figure 4 shows that this can be done from the CALS-formatted Deliverable Files, either in a database or in the deliverable package.

The following section provides a more comprehensive description of each of the functional blocks within the Product Data Generation process.

6.1 Generate Product Data (P3.1)

This functional block includes the total development starting at contract award. The prime and many subcontractors may be involved in the development as well as the government in the technical review process. For the purpose of this model it is assumed that these have been completed and that final production engineering drawings (Level III) are in preparation.

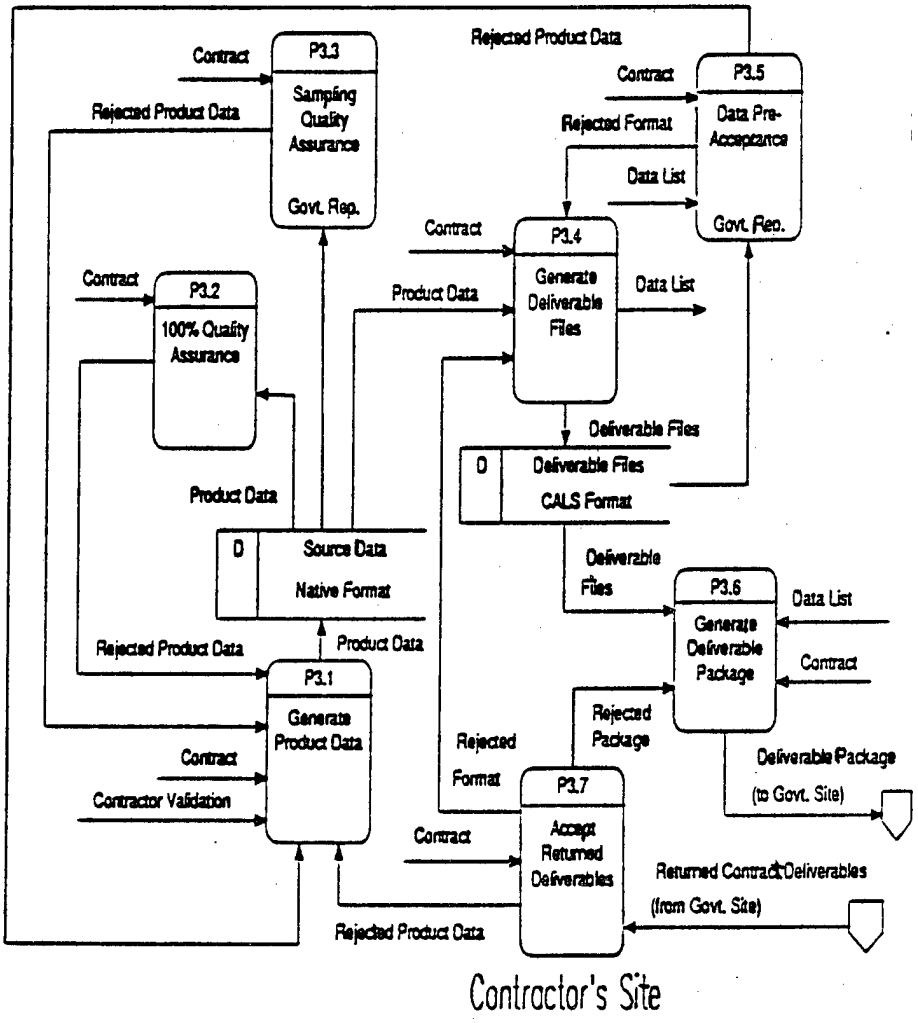

Figure 4 - Product Data Generation

The product data may come from a variety of sources, especially for a major weapon system procurement. The prime contractor may develop the engineering documentation on CAD/CAE/CAM systems, manual drafting, or a combination of both. Subcontractors may deliver data via hard copy or aperture cards. This data must be converted and delivered in CALS-compliant format. Regardless of the native format of the source, the quality of the product data must be maintained during these conversion processes.

The Generate Product Data functional block of Figure 4 shows a number of inputs. The Contract shown is, of course, key to defining the requirements for the development of new data and handling of rejected data as well as defining the criteria for the acceptance of data at the contractor and government site. The product data may be rejected at a number of places during the development as shown in Figure 4. At either the contractor's site or the government site, product data files or identification data may be rejected. At the government site, quality and identification data errors may result in returning the entire deliverable package, one or more magnetic tape or optical disk volumes, or even a data list which identifies the rejected drawings with description of the type errors by drawing number or some other identification. These rejected files, media, or data lists will then be regenerated. The corrected data may be reviewed again by the on-site government representative or for small quantities may also be returned to the user for review and acceptance. This data must be corrected and is therefore shown as inputs to this functional block.

The contractor generates new data from the various information data sources (hard copy, aperture cards, CAD) and converts and stores the data, in native format, on his Source Product Data database.

6.2 100% Quality Assurance (P3.2)

As required by the contract, the contractor performs 100% quality assurance on the data in the contractor's own source product data base. This is done before any deliverables are generated. Any product data rejected by the contractor is re-generated by Product Data Generation and replaced in the source data base. The contractor will certify that 100% QA has been completed. The government representative will verify that the contractor has performed 100% quality assurance by reviewing the contractors certification documentation as well as QA records when required.

6.3 Sampling Quality Assurance (P3.3)

The qualified government representative may perform sampling quality assurance on the data in the contractor's source data base if the contract specifies. The sampling will require use of the contractors image workstation or a compatible workstation if remote access to the data base is a contract requirement. The implementation of this step is contract dependent and may be more appropriate for major weapon system procurement. The sampling QA may be performed during the process of generating the data or after a defined file set of product data has been completed by the contractor and prior to conversion of the data to CALS-compliant format.

Any files rejected by the government representative's sampling QA are re-generated at this stage by the Product Data Generation function and replaced in the source data base for QA by the government representative prior to generation of the deliverable CALS-compliant files.

6.4 Generate Deliverable Files (P3.4)

The contractor generates the deliverable files in CALS-compliant format as required by the contract and a separate data list file on the deliverable medium specified by the contract. The separate data list is created to itemize the deliverables generated and to be used by the government agency to track the data during the acceptance process.

This function also encompasses the re-generation of deliverable files which are rejected by the format verification procedure during pre-acceptance. The deliverable files may have been rejected at one or both of two points in the product data procurement process. They may have been rejected by the government representative's pre-acceptance at the contractor site or they may have been returned to the contractor after being rejected at the government user site.

6.5 Data Pre-Acceptance (P3.5)

This functional block is the recommended area for the application of computer-assisted techniques. Application software will apply these techniques to inspect image quality and identification data quality of the deliverable files. Visual sampling will then be performed on the deliverable files. Pre-acceptance may be performed on the deliverable media of the Deliverable Package or on the Deliverable Files Database. Pre-acceptance may be performed on a stand-alone

workstation or on an existing system. Equipment may be contractor-furnished or government-furnished.

Product data rejected at this stage due to quality will be re-generated, converted and returned to the deliverable data base for review. Identification data and format rejections will also be corrected prior to delivery. The media format verification application software can only be applied if the deliverable media is checked by the government at this time.

If the data passes pre-acceptance via CALS Deliverable Files review then the contractor may prepare the data for delivery by the Generate Deliverable Package function. If pre-acceptance was conducted on the deliverable media, all that would be required is the packaging of the media for shipment. See section 8.0, Data Pre-Acceptance, for additional details.

6.6 Generate Deliverable Package (P3.6)

Upon satisfactory completion of the government performed pre-acceptance, the data may be prepared for delivery. The extent of the preparation depends on whether the pre-acceptance was performed on the deliverable media or on the CALS-compliant Deliverable Files database.

The contractor will prepare the contract defined documentation to be delivered with the data and the data list. The data list may be hard copy only, in electronic format or both. If in electronic format it is recommended that this be on magnetic tape initially and perhaps floppy disk in the future.

If the government has performed pre-acceptance on the deliverable files then the contractor will package, the government will inspect and it will be shipped to the government user site.

One of the inputs to the Generate Deliverable Package functional block is Rejected Package. If a previously delivered package was returned due to damage, then it may be repackaged and reshipped.

6.7 Receive (Accept) Returned Deliverables (P3.7)

The contractor receives returned product data from the government site in part or in whole. The returned deliverable may be the entire package or one or more files of data. The contract-specified rejection criteria may include poor image quality,

poor or inaccurate identification data, improper media or data format, missing or inaccurate data list, or improper packaging.

The returned deliverable is re-generated with the appropriate functional block. A returned deliverable package is re-generated by the Generate Deliverable Package functional block while files returned due to rejected format may be re-generated by the Generate Deliverable Files functional block. Product data returned due to poor image quality will be regenerated by the Generate Product Data functional block. The Returned Contract Deliverables may take the form of an electronic data list which identifies the rejected data by drawing number and describes the reason for rejection. Support hard copy may be a contract requirement. The contractor can view his CALS-compliant Deliverable Files database or look at the rejected data by drawing number in his native Source Database. Regeneration can then commence from this point.

7.0 PRODUCT DATA ACCEPTANCE

The Product Data Acceptance process of Figure 5 shows the data flow and functions required to receive, accept, reject, translate and store product data at the government user site. Again, "Product Data" is used to represent Raster Type I, Raster Type II, or IGES data.

Each of the functional blocks is sequentially numbered (P4.1,P4.2, etc) to assist in following the flow for product data acceptance at the government user site. The input and output items, depicted by arrows, include Contract, Data List, Product Data, and Rejected Product Data.

Data may be received from the contractor and rejected data returned to the contractor on physical media or via telecommunication. Date transmitted by telecommunications will be stored temporarily.

As shown in Figure 5, the data package, which includes the data list, will be accepted in accordance with the contract requirements and the delivered files will be temporarily stored in a Deliverable Files database. At this point the data may undergo pre-acceptance and upon acceptance may then be translated from the CALS format to the repository native format. The pre-acceptance step is an optional step that is not recommended if full contractor on-site pre-acceptance has been performed. If Data Pre-acceptance has been performed, it is recommended that the government only conduct sampling QA of the product data for Final Acceptance. This should be a contract defined option and will be guided by the individual contractor performance history. Upon acceptance, the data will be permanently stored within the government engineering drawing repository.

The following sections provide a more comprehensive description of each of the functional blocks within the Product Data Acceptance process flow shown in Figure 5.

7.1 Receive (Accept) Package (P4.1)

The contractor site pre-acceptance has been completed and the contractor transports the deliverable package in the contract defined media to the government user site. The government inspects the deliverable package in accordance with the contract requirements. Acceptance of the delivered data package via telecommunication means will require, as a minimum, techniques for validating that the data information sent was received. Acceptance of the physical package requires that the physical package complies with the contract packaging and

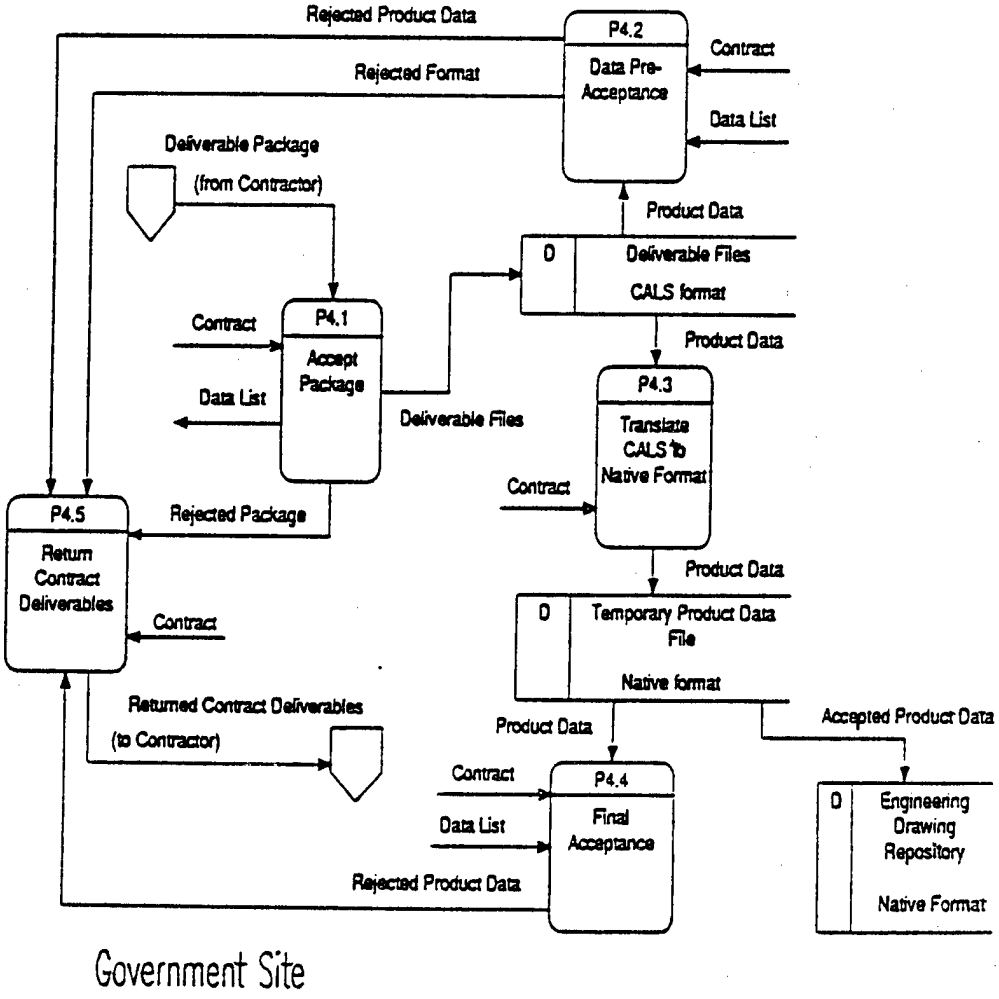

Figure 5 - Product Data Acceptance

shipping requirements. The deliverable files and data list may now be made available to the government agency or group responsible for data pre-acceptance or translation to native format. A deliverable package that fails to comply with the contract requirements or is damaged is rejected and returned to the contractor.

7.2 Data Pre-Acceptance (P4.2)

The deliverable data is imported, in CALS format, to a Deliverable Files database. Data Pre-Acceptance may be performed at this time prior to translation or it may be omitted if the contract specifies data pre-acceptance at the contractor's site. The pre-acceptance may be run on a stand-alone or front-end platform which will accept the delivered media directly for computer-assisted format and data verification in a batch mode and then deliver the verified data files or media to the repository host computer. Pre-acceptance may also occur by use of the repository resources that will accept or contain Data Pre-Acceptance software that will perform the image quality and identification data verification in a batch or background mode. Another possibility, for the implementation of the computer-assisted data pre-acceptance procedures, would be to import the software to a stand-alone or front-end compatible platform that is used for translation only.

See section 8.0, Data Pre-Acceptance, for additional details.

7.3 Translate CALS to Native Format (P4.3)

Upon satisfactory completion of Data Pre-Acceptance, the accepted deliverable CALS formatted files will be translated to the repository's native format. After translation, the product image and identification data will be temporarily stored, in native format, in the repository's temporary image file database.

The translation process should not degrade the data quality. However, in any computer system, environmental conditions, power failure, or other anomalies may introduce soft errors into the data. It is therefore recommended that Final Acceptance sampling of the native data be performed.

7.4 Final Acceptance (P4.4)

The translated product data located in the repository temporary image file database must undergo visual inspection prior to loading into the Engineering Data Repository. This final acceptance of the product data will utilize the existing resources of the repository for the QA of image data.

If full pre-acceptance has been performed then this visual acceptance should be a sampling of the data only. However this is a contract-specific option for each government user and will depend on such factors as the contractor/user performance history, volume of data procured, contractor-site pre-acceptance performed, user-site pre-acceptance performed, statistical results of the pre-acceptance DA testing, and contract performance period.

Figure 5 shows that the Rejected Product Data will be returned to the contractor for resolution. If Data Pre-Acceptance is performed at the user site then the probability is that the Final Acceptance rejects will be minimal. It is recommended that any files rejected during Final Acceptance be validated by testing the identical CALS-compliant file to insure that the cause for rejection is in the contract deliverable and was not introduced in the translation process.

Satisfactory Final Acceptance will result in completion of any contract specified documentation such as acceptance reports, letters of acceptance and ultimately completion of DD250s for final acceptance.

7.5 Return Contract Deliverables (P4.5)

The government user will assemble a package of rejected contract deliverables which are to be returned to the contractor. The content of the returned deliverables will depend on both the rejected items and the contract requirements. For example, in the case of a rejected package due to improper shipping, the entire package will be returned to the contractor. In the case of one or more rejected files in a single volume, the entire volume or the entire package may be returned.

Product data that must be returned to the contractor must be returned in the CALS-compliant format. This means that all product data rejected during Final Acceptance must be inspected in the CALS-compliant format as they were received from the contractor. Digital data provides alternatives for the handling of rejected product data. If the contractor has retained a CALS-compliant deliverable files database, then the contract may specify returning only a Data List of the rejected product data. The contractor can then verify if the deliverable data were defective. If the CALS-compliant deliverable files database is not available, then the source native Product Data database may be checked.

8.0 DATA PRE-ACCEPTANCE

Computer-assisted data pre-acceptance of product data extends the ability of a government agency to ensure that all product data received from a contractor and stored in a repository is of high quality. This is accomplished by the application of computer-assisted quality assurance techniques to inspect an entire image database with no human intervention, to find image quality problems, and to summarize them in a report. Qualified personnel can then review the report and visually inspect a sample of images to confirm the results of the automated procedures. The images with reported problems can then be visually inspected for acceptance or rejection. From the images with no reported problems a statistically sampled number can be visually inspected to confirm that there were no problems. Data pre-acceptance is shown in Figure 6.

Data quality pre-acceptance of product data is performed at key points in the procurement process. It is site-independent because it can be performed at the contractor site, subcontractor site, and the government site. It is also platform-independent because it can be performed on a repository system, a front-end to the repository system, or a stand-alone system.

Data pre-acceptance is especially important in inspecting image quality of converted hard copy or aperture card data. An unacceptable image may be generated from a marginally-acceptable source image. It may have suffered quality degradation due to age and handling. The image scanning and generation process may introduce noise which compounds that already present in the source image.

Computer-assisted techniques can be used in data pre-acceptance to achieve a higher level of quality assurance than would be possible solely by manual handling and visual inspection of images. The benefit is even more profound when large volumes of digital image data are involved because computer-assisted techniques can operate on 100% of the images. Visual inspection of large volumes of images to find poor quality images is a labor-intensive and error-prone task. The productivity of visual inspection can be improved by focusing it to those images which were reported to have problems by computer-assisted techniques. Human judgement can then be applied to accept or reject them.

Computer-assisted techniques are applied to three specific areas of interest: data format, image quality, and image identification data.

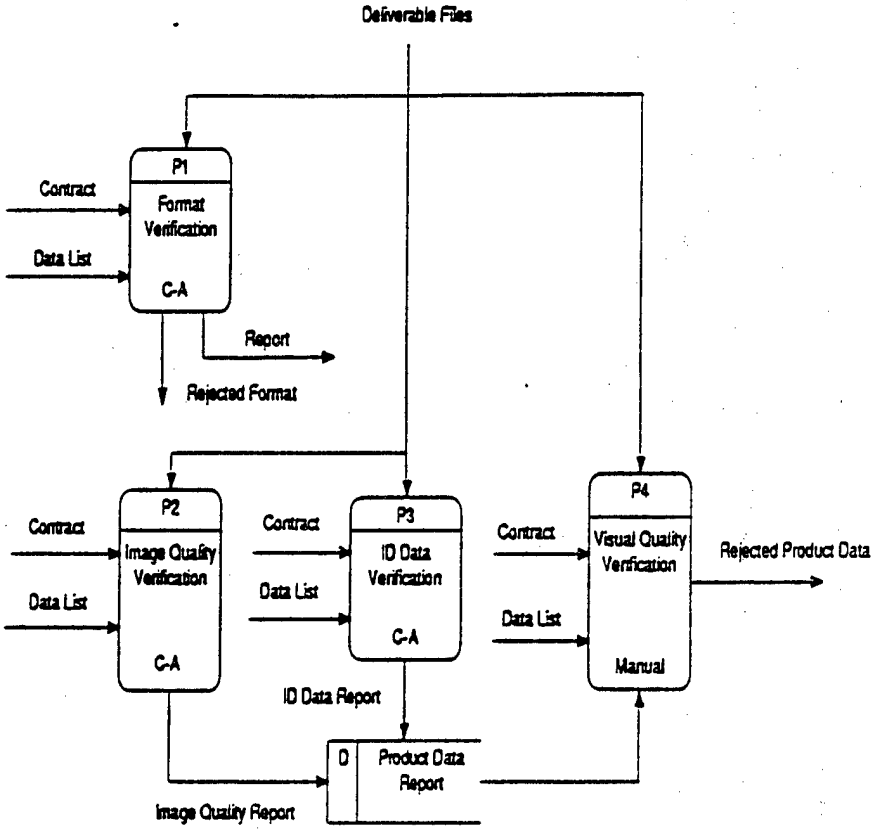

Figure 6 - Data Pre-Acceptance

8.1 Format Verification (P1)

The format of the deliverable files is verified for compliance with MIL-STD-1840A specifications.

There may be a separate tool whose sole function is to verify the format of the deliverable files on a magnetic tape or other CALS-compliant media, to be specified in the future, and present a comprehensive report of problems encountered.

However, the verification may be only the first step in the translation done by translation software. In this case, the only reporting may be a message that the translation cannot be done due to an input format error; a successful translation would imply that the input format was in the expected CALS-compliant format.

For physical media, the format of the deliverable files can be verified on the deliverable medium. For telecommunications media, the format of the deliverable files can be verified on the receiving system's file system.

8.2 Image Quality Verification (P2)

Image quality verification is a computer-assisted technique which examines a digitally-stored image and reports the quality of the image with respect to specific quality criteria. Image quality verification is primarily applicable to raster images which were converted from hard copy or aperture card source data.

Image quality may be checked with respect to information contrast to detect images that are too light or too dark. Image quality may be checked with respect to image-to-image contrast range.

Image quality may also be checked with respect to image noise. The image file is checked for black and white orphans. An orphan is a pixel or a small group of pixels which is completely surrounded by the contrasting color. A black orphan is a dark orphan surrounded by white space. A white orphan is a white speckle in a filled-in image area, e.g. a line, a character, etc. An orphan is likely to represent noise introduced in the image generation process rather than image data.

Image quality may be checked with respect to verticality to detect images that are skewed. An excessively skewed drawing is likely to be missing parts of an image due to cropping at the corners.

8.3 Image ID Data Verification (P3)

Image ID Data Verification is a computer-assisted technique which obtains ID data from a digitally-stored image, compares it with the ID data in the deliverable header, and reports discrepancies between the two. These two may also be compared with a contractor-furnished data list if the contract specified that it be furnished in digital format.

For raster images, the ID data can be obtained from the image file by applying character recognition techniques to convert information in the title block area to ASCII text.

For vector, i.e. IGES, product data, the ID can be obtained from the product data file directly by searching for text which is located in the title block area.

8.4 Visual Image (Quality) Verification (P4)

This is a visual inspection of digital images which will be performed using a high-resolution monitor on a graphics workstation. The workstation may be a part of an existing repository system, a part of a front-end system, or a stand-alone system. The workstation used for visual inspection can be a part of the platform used for computer-assisted techniques or it may be a separate platform.

The amount of visual inspection required is dependent on the quality of the digital data provided by the contractor.

The government representative will review the rejection report obtained from the completion of the batch analysis of the data by the Image Quality and Image ID Data Verification software. The government representative may choose to now look at the rejected data as a final check.

The final step in the Pre-Acceptance testing of the deliverable data will be to conduct a statistical sampling of the data accepted by the computer-assisted batch analysis process.

Based on the results of the Visual Image Verification, the deliverable data can be accepted or rejected.

9.0 CONCLUSIONS

The digital data acceptance model presented in this document has captured the essential data and process flow for the generation, validation and acceptance of product data, beginning at the contractor site and ending at the government site. As each functional block in the model is expanded in greater detail, the implications and relationship among the native image processing systems at both contractor and government sites, the CALS conformance requirements, and the computer-assisted techniques for data quality assurance become evident. Computer-assisted digital data acceptance is feasible and desirable, but certain adjustments to the existing manual data acceptance procedures must be made. Specifically, this model emphasizes the placement and execution of data pre-acceptance, sampling quality assurance and 100% quality assurance. Each of these functions can be done effectively only if the data has been prepared in the appropriate format and subjected to configuration control.

The model also indicates that the data pre-acceptance function will benefit the most from computer-assisted techniques. For engineering drawing digital data, techniques have been identified for data format verification, image quality evaluation and image identification tracking. The extent of the applicability of computer-assisted techniques to the model's Data Pre-Acceptance process can best be determined by simulation and testing of the techniques. Simulation and testing will also allow for performance projections when dealing with large quantities of data.